COMMUNICATIONS

VOLUME 33, NUMBER 11

OF THE ACM

NOVEMBER 1990

COMMUNICATIONS OF THE ACM November 1990

WOMEN & COMPUTING

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There is mounting evidence that many women opting for careers in computing either drop out of the academic pipeline or choose not to get advanced degrees and enter industry instead. Consequently, there are disproportionately low numbers of women in academic computer science and the computer industry. The situation may be perpetuated for several generations since studies show that girls from grade school to high school are losing interest in computing.

Statistics, descriptions offered by women in academic and industrial computing, and the research findings reported later in this article indicate that much is amiss. But the point of what follows is not to place blame—rather it is to foster serious reflection and possibly instigate action. It behooves the computer community to consider whether the experiences of women in training are unique to computer science. We must ask why the computer science laboratory or classroom is "chilly" for women and girls. If it is demonstrated that the problems are particular to the field, it is crucial to understand their origins. The field is young and flexible enough to modify itself. These women are, of course, open to the charge that they describe the problems of professional women everywhere. But even if the juggling acts of female computer scientists in both academia and industry are *not* particular to computing, American society cannot afford to ignore or dismiss their experiences; there is an indisputable brain drain from this leading-edge discipline.

A look at statistics reveals a disquieting situation. According to Betty M. Vetter, executive director of the Commission on Professionals in Science and Technology in Washington, DC, while the number of bachelor's and master's degrees in computer science are dropping steadily for both men and women, degrees awarded to women are dropping faster, so they are becoming a smaller and smaller proportion of the total. Bachelor's degrees peaked at 35.7% in 1986, masters also peaked that year at 29.9%, and both are expected to continue to decline. "We have expected the numbers to drop for both, due to demographics such as fewer college students," says Vetter, "but degrees awarded women are declining long before reaching parity." (See Table I.) Vetter also would have expected computer science to be "a great field for women," as undergraduate mathematics has been; female math majors have earned 45% of bachelor's degrees during the 1980s. On the other hand, math Ph. D.'s awarded to women have gone from only 15.5% to 18.1% in this decade, which is more in line with computer science Ph.D.'s earned by women. In 1987, 14.4% of all computer science Ph.D's went to women; this number declined to 10.9% the following year. Although the number almost doubled between 1988 and 1989 with women receiving 17.5% of Ph.D.'s, Vetter points out that the number remains very small, at 107. Since these figures include foreign students who are principally male, women constitute a smaller percentage of that total than they do of Ph.D.'s awarded to Americans. But while American women received 21.4% of Ph.D.'s awarded to Americans, that is not encouraging either, says Vetter. Again, the *number* of American women awarded computer science Ph.D.'s was minuscule, at 72. And taking a longer view, the awarding of significantly fewer bachelor's and master's degrees to women in the late 1980s will be felt in seven to eight years, when they would be expected to receive their Ph.D.'s.

How do these figures compare with those of other sciences and engineering? In her 1989 report to the National Science Foundation, "Women and Computer Science," Nancy Leveson, associate professor of information and computer science at the University of California at Irvine, reports that in 1986, women earned only 12% of computer science doctorates compared to 30% of all doctorates awarded to women in the sciences. Leveson notes, however, that this includes the social sciences and psychology, which have percentages as high as 32 to 50. But the breakout for other fields is as follows: physical sciences (16.4%), math (16.6%), electrical engineering (4.9%), and other engineering ranges from 0.8% for aeronautical to 13.9% for industrial.

Those women who do get computer science degrees are not pursuing careers in academic computer science. Leveson says women are either not being offered or are not accepting faculty positions, or are dropping out of the faculty ranks. Looking at data taken from the 1988–89 Taulbee Survey, which appeared in *Communications* in September, Leveson points out that of the 158 computer science and computer engineering departments in that survey, 6.5 percent of the faculty are female. One third of the departments have no female faculty at all. (See Tables III and IV.)

Regarding women in computing in the labor force, Vetter comments that the statistics are very soft. The Bureau of Labor Statistics asks companies for information on their workforce, and the NSF asks individuals for their professional identification; therefore estimates vary. Table II shows that this year, women comprise about 35% of computer scientists in industry. And according to a 1988 NSF report on women and minorities, although women represent 49% of all professionals, they make up only 30% of employed computer scientists. "There is no reason why women should not make up half the labor force in computing," Betty Vetter says, "It's not as if computing involves lifting 125 pound weights."

The sense of isolation and need for a community was so keen among women in computing, that in 1987 several specialists in operating systems created their own private forum and electronic mailing list called "Systers." Founded and operated by Anita Borg, member of the research staff at DEC's Western Research Lab, Systers consists of over 350 women representing many fields within computing. They represent 43 companies and 55 universities primarily in the United States, but with a few in Canada, the United Kingdom, and France. Industry members are senior level and come from every major research lab. University members range from computer science undergraduates to department chairs. Says Borg, "Systers' purpose is to be a forum for discussion of both the problems and joys of women in our field and to provide a medium for networking and mentoring." The network prevents these women, who are few and dispersed, from feeling that they alone experience certain problems. Says Borg, "You can spit out what you want with this group and get women's perspectives back. You get a sense of community." Is is sexist to have an all-women's forum? "Absolutely not," says Borg, "It's absolutely necessary. We didn't want to include men because there is a different way that women talk when they're talking with other women, whether it be in person or over the net. Knowing that we are all women is very important." (Professional women in computer science who are interested in the Systers mailing list may send email to systers-request@decwrl.dec.com)

The burden from women in computing seems to be very heavy indeed. Investigators in gender-related research, and women themselves, say females experience cumulative disadvantages from grade school through graduate school and beyond. Because statistical

Graduate School in the Early 1980s:

"I was on the computer and something happened. I didn't know what was going on. I saw a guy who looked like a real hacker. So I asked him, and he got up, and he started doing all this stuff with my account without telling me what he was doing. He started messing around, 'You need this. Let's see, I'll give you this file.' It's like, what are you doing? He wouldn't tell me."

"I am uncomfortable about asking certain male graduate students for help (about the system, projects, etc.) because it might be viewed as 'coming on' to them. More times than not, the answer to a question is followed by an invitation to go out."

"I've heard several teaching assistants come to the conclusion that women always ask for help more than men, with an implication that women can't figure things out on their own."

"I was told by a male faculty member that women do not make good engineers because of early childhood experiences . . . little boys build things, little girls play with dolls, boys develop a strong competitive instinct, while girls nurture . . ."

"Stereotypes make it harder for me to work here because they reinforce the idea that I can't be a good engineer. This attitude is pervasive. It affects other people's behavior toward me as well as my own self-image."

"You want to do research? Let me see what I have that you can do . . . This paper needs proofreading."

"There is a picture of a nude woman on our system which is printed out and displayed. It is also used occasionally to demonstrate the graphics capabilities of the system."

In "The Garden [at MIT's Media Lab] . . . some faculty, students, and staff [chose] a test sequence from a film clip of the TV program 'Moonlighting'. They were looking for a sequence of a few frames that had a variety of colors, textures, and camera motions, and that probably had human figures on it. On these strictly technical considerations, they chose a sequence in which, at the beginning, the camera focuses closely on the legs of Cybil Shepherd as she walks away from the camera in a torn skirt. Subsequent frames show her walking flirtatiously past Bruce Willis, pretending to be angry at him but with a small, triumphant smile on her face . . . Women must deal with these pictures of women as test objects, as pictures to be used over and over again, long after their anger has worn off."

"Because men always think that I'm coming on to them, I don't feel comfortable joining technical bull sessions. I feel as if I'm missing a valuable part of my graduate education."

TABLE I. Computer Science Degrees Awarded in the United States

	1980	'86	'87	'88	'89
Total Bachelors	11,213	42,195	39,927	34,896	NA
women	3,399	15,126	13,889	11,353	NA
% women	30.3%	35.7%	34.8%	32.5%	
Total Master's	3,647	8,070	8,481	9,166	NA
women	764	2,412	2,496	2,464	NA
% women	20.9%	29.9%	29.4%	26.9%	
Total Ph.D.'s	218	399	450	514	612
women	21	48	65	56	107
% women	9.6%	12.0%	14.4%	10.9%	17.5%
US. Ph.D.'s	156	202	243	284	337
US women Ph.D.'s	19	37	50	39	72
% US women	12.1%	18.3%	20.6%	13.7%	21.4%

Data obtained from Betty Vetter, author, forthcoming Ninth edition of *Professional Women and Minorities*, published annually by the Commission on Professionals in Science and Technology.

TABLE II. Bureau of Labor Statistics on Persons Employed in Computing

	Computer systems analysts	Operations and systems	Mathematical and Computer Scientists (total)
1990 Total	56,000	239,000	805,000
% women	32.4%	41.1%	35.7%
1982 Total	242,000	246,000	488,000
% women	26.4%	31.7%	29.0%

Data obtained from Betty Vetter, as in Table I.

TABLE III. 1988–89 Taulbee Survey Data for all Faculty
(This survey includes 129 CS departments and 29 CE departments)

	CS faculties			CE faculties			CS+CE		
Professors	**Total**	**Women**	**%**	**Total**	**Women**	**%**	**Total**	**Women**	**%**
Asst.	938	92	10	204	11	5	1142	103	9
Assoc.	718	66	9	191	8	4	909	74	8
Full	894	30	3	295	3	1	1189	33	2.7
Total	2550	188	7	690	22	3	3240	211	6.5

TABLE IV. Distribution of Female Faculty (1988–89 Taulbee Survey)

# Females	Asst. # depts	Assoc. # depts	Full # depts	All Ranks # depts
4+	1	2	0	9
3	3	1	1	17
2	20	10	4	31
1	50	40	22	54
0	84	105	131	47

ise that the decline in the number of women selecting computer science majors can be attributed to a male-oriented paradigm in the field. Martin invited 12 scholars (See Workshop Participants, p.) conducting gender-related research in computer science education to present their latest findings and to participate in brainstorming sessions that resulted in recommendations. Highlights of the day-long workshop follow.

In her opening statement, Martin noted that many researchers observe that the computer culture is uncomfortable for girls and women. They are ill at ease in a field that seems to encourage "highly focused, almost obsessive behavior," as the key to success she said, summarizing comments by Eric Roberts at a recent Washington student society (Pugwash) meeting. She also alluded to perceived sex biases in the profession, citing two recent national statistical studies of female engineers and female undergraduate engineering students by Eleanor Baum, Dean of the School of Engineering at Cooper Union. Baum's investigations showed that 70% of women felt they had to work harder than their male counterparts to get comparable pay, 58% felt that harassment of some sort was prevalent in the workplace, 50% felt that they viewed ethical issues differently than did their male counterparts, 39% felt they would be penalized if they took maternity leave, and a whopping 78% felt they received comparable pay when they started, but were not promoted as rapidly. A third, independent study supported the last belief; while women started out with comparable pay, within 10 years they were 25% behind their male counterparts. (*Businessweek* 8/28/89)

Chaos in Computer Classrooms

Lesley S. Klein, instructor of information systems at Pace University and a computer science teacher in middle school and high school, de-studies frequently come under fire and do not always explain the entire picture, it is important to listen to how women themselves tell their story. In the Sidebar entitled "Graduate School in the Early 80s," women describe experiences of invisibility, patronizing behavior, doubted qualifications, and so on. Given these experiences, it is not surprising that many women find the academic climate inclement. But while more women may choose to contribute to research in industry, is the computer business really a haven for women, or just the only alternative? In the Sidebar entitled "The Workplace in the late '80s," women in industry also tell their story and describe dilemmas in a dialogue on academia versus industry; this discussion erupted freely last Spring on Systers. In addition, findings of scholars conducting gender-related research are presented in a report of a workshop on women and computing. Finally, *Communications* presents "Becoming a Computer Scientist: A Report by the ACM Committee on the Status of Women in Computer Science." A draft was presented at the workshop and the report appears in its entirety in this issue.

Report on a Meeting

To probe further into the reasons why girls and women are not pursuing computing in the same numbers as boys and men, and to recommend ways to reverse this trend, a workshop was held at the National Educational Computing Conference last June. This year, this influential and decade-old conference drew 2,414 authorities in computing and education and 1,500 people from industry. Entitled "In Search of Gender-Free Paradigms for Computer Science Education," the workshop was organized and chaired by C. Dianne Martin, an assistant professor at George Washington University's Electrical Engineering and Computer Science department. Its specific goal was to examine the prem-

Female Students Lament

"Professor Jones and I were working late on a project, and we decided to grab something to eat. I thought we'd go for a sandwich. Imagine how I felt when we drove up to a fancy, candle-lit restaurant. I didn't want to go in because it seemed too much like a date situation, but he insisted and also wouldn't let me pay for my dinner. I felt as if I had been forced into going on a date with him, and after that I always felt nervous being alone with him."

"While talking with a male colleague in my office, he suddenly placed his hand on my breast and said he liked me."

"While I was teaching a recitation section, a male graduate student burst in and asked for my telephone number. Men often interrupt me during technical discussions to ask personal questions or make inappropriate remarks about nonprofessional matters."

"When I was a teaching assistant, one of my students missed the lecture and saw me later. He said, "Will you come sit on my lap sometime and tell me what I missed? . . . "

"If, during a technical meeting, a sexist comment is made, all eyes turn to me for my reaction. Not only am I constantly in the spotlight, but men think it is all right to make sexist comments during technical meetings, even when I am in the room."

"I was told by a secretary planning a summer, technical meeting at an estate owned by MIT that the host of the meeting would prefer that female attendees wear two-piece bathing suits for swimming."

"We don't want it to seem like we're saying all attention is bad. We want the men to treat us as well-rounded people, which includes desire for human relationships. The problem with the attentions we receive now is that our freedom of choice is ignored."

Note: The first comment was made by a first-year student describing her initial socialization into the culture of computing, according to Kielser, Sproul, and Eccles (See Additional Reading). The "Moonlighting" comment comes from Jenifer Tidwell's description of MIT's " Terminal Garden" in an unpublished paper written in the spring of 1990. All other comments are from "Barriers to Equality in Academia: Women in Computer Science at MIT," prepared by female students and research staff in the Computer Science and Artificial Intelligence Labs, February 1983. By extensively quoting this report, *Commun. ACM* does not mean to single out MIT. Sources say the experiences of those quoted here are typical of women in computing everywhere.

scribed the chaotic state of computer science education throughout pre-college levels. Working under the auspices of the Board of Cooperative Educational Services, funded by New York State Department of Education, Klein observes upper middle income schools of this public school system. Despite its relative wealth, there is often a low budget for computer science and no curriculum, she said. Computing is taught by teachers' aides or by media center administrators who have had in-service training. "Occasionally students are fortunate to have a classroom teacher who has an interest in computers as a hobby or has taken some computer education courses," Klein reports in her paper, "Female Students' Underachievement in Computer Science and Mathematics: Reasons and Recommendations." "Some more adventurous teachers have incorporated LOGO or Lego Logo programming into the curriculum, but there is no apparent formal plan nor carryover from one grade level to the next," Klein continues. There are neither goals nor minimum standards established for both teacher training and the material to be covered. Not until the seventh and eighth grades does the study of computers, logic, or BASIC programming emerge. PASCAL and C programming and introductions to data processing are offered in secondary schools, but there is still great variation in instructors' backgrounds and levels of competence. Some are math teachers, have master's degrees in computer science, or have taken graduate courses, but others are industrial arts teachers who have received minimal training. On the other hand, sometimes industrial arts teachers are better qualified than math teachers. Although high school curricula for computer literacy and computer science courses do exist (ACM made several recommendations on curricula five years ago and plans to revise them by 1991) there is little support to implement them and there is no uniformity from state to state.

But one would expect this sorry state of affairs to affect boys and girls equally. Not so. According to Klein, girls "demonstrate more insecurity and lack of self-confidence in math and science during transition periods" like entering middle school and entering high school. In middle school, for example, boys use pirated software, she says, and the girls follow the school rules and are in the boys' way. "The computers are always consumed by the boys who rush in, desperate to continue where they left off the day before in Oregon Trail, Karateka, or Carmen San Diego. An occasional girl wanders in, but would practically need interference from the heavens to gain access to these monopolized computers," Klein says. Given these different styles of behavior, Klein sees the need for a formal computer science curriculum for grades seven through twelve as well as a mandatory requirement that every high school student take an introduction to computer science. Because many in the educational community are unaware that recommended curricula exist, Klein stresses the need for support for the distribution and implementation of curricula. In addition, there should be more uniform teacher training that improves computer skills and lesson presentation while "specifically addressing the motivation of female students."

Women and Girls of Color

The problems in computer science education for girls in well-to-do schools are substantial, but they are mild in comparison to those that girls from minority groups face in their schools. Carol E. Edwards, of the Southern Coalition for Educational Equity, Atlanta, Georgia, addressed the implications of the computer culture for girls and women of color. As the director of Project Micro, Edwards runs a program devoted to making personal computers available to minority children and to using those computers to teach higher-order thinking skills. The educational opportunities for these women and girls are so poor, she said, that they amount to racial, ethnic, and class discrimination. Both boys and girls of color go to schools with low teacher expectations, more substitute teachers, less experienced teachers, and frequent relegation to lower educational tracks. In math, for example, girls of color are disproportionately represented on slower tracks.

Tracking itself is part of systemic problems in minority schools; it is an example of structural practices that remain instituted even though they have been shown to benefit only the top one % of students, Edwards said. Besides these educational barriers, both boys and girls of color face cultural barriers such as lack of role models and lack of parental encouragement. They lack science-related opportunities and often never see computers. But if they do use computers, they are not likely to stay after school in the computer lab. That is seen as scholarly and boys of color measure self-esteem in nonacademic ways, she said. Girls are unlikely to stay after school because they are usually responsible for younger siblings at home. These barriers lead to disadvantages that are cumulative; the combination of being poor, a member of a minority, and female lowers perceptions and attitudes toward math and computers proportional to the level of disadvantage, she said.

Sex-Biased Software

Any computer science curriculum, whether implemented in a wealthy or disadvantaged school must involve the selection of software. But studies show sex bias in educational software. In an effort to understand why the computer "is more alluring to boys than it is to girls," Charles W. Huff and Joel Cooper have found sex biases due to the stereotypes of software designers. Huff, who was with Carnegie-Mellon University during this research and is now an assistant professor of psychology at St. Olaf College, Northfield, MN, briefly presented their findings to the workshop. Because their results are far-reaching and possibly related to software use in the workplace, Huff's comments as well as those from an interview with Cooper, chairman of Princeton University's Department of Psychology, are presented here.

Beginning with sex differences in the impact of television violence on children, Cooper is the author of many gender-related studies and has collaborated with other researchers (including Joan Hall, Lori Nelson, Diane Mackie, all from Princeton, and Gita Wilder of the Educational Testing Service). Although the media has reported the general conclusion that televised violence makes children act more aggressively, on closer inspection of the data Cooper found this "true almost exclusively for boys, not girls." Most investigators stopped studying girls because the early data showed no effect so as they proceeded with their research they used only males. "It is an important observation that boys become more aggressive when they watch television, but it should be equally interesting that girls don't," Cooper says. He and his colleagues wondered whether the difference was due to different processes in males and females or to a predominance of male TV heroes and villains. They also decided to investigate the impact of aggression via other media, particularly video games and middle school children. At that time, the early 1980s, graphics were so primitive that characters were neither male nor female. This allowed the researchers to introduce aggressive and nonaggressive video games without concern for the sex of the protagonists and antagonists. In that study, girls who played aggressive video games became more aggressive than boys did. Says Cooper, "the impact was greater on girls than on boys." But Cooper also observed that when they told the children they were going to play a video game like Missile Command, the boys got very excited but the girls were unenthusiastic. They said either "I don't want to play that," "I can't play that," or "I'm not good at that." In fact, the girls were quite good at playing such games. "They were just as good at it as the boys were," said Cooper, "But what they were telling us was quite significant. They were saying, 'This makes me very, very nervous, especially to do it in front of you.'"

In another classroom in the same school, computerized learning had just begun with educational software having a metaphor much like Missile Command. "In order to motivate kids, educators were using a metaphor or fantasy that our research showed was extremely exciting for boys and anxiety producing for girls," Cooper explains. Next, he and Huff "hypothesized that the expectations software designers hold about the users of software they design are central in determining the way the user and the software interact."

To test this social psychological model—that expectations of one person about another can shape their interaction—Huff and Cooper asked educators with programming experience to design software for either boys, girls, or students. The programs for both boys and students were the most game-like whereas those intended for girls were classifiable as learning tools. "Programs written for students are written, it seems, with only boys in mind," Huff and Cooper write in "Sex Bias in Educational Software: The Effect of Designers' Stereotypes on the Software They Design." ". . . That is, [male and female designers] may have been simply using "male" as the default value of "student." Therefore, "It is not the computer, or even the software, that is at the root of the sex bias in software, but the expectations and stereotypes of the designers of the software," Huff and Cooper conclude.

One obvious implication of this male bias is that educational software may be designed to appeal to boys "without consideration of the effect on girls' motivation to use them or on girls' educational profit from them. This certainly cannot be a good thing." Children using software designed for the opposite sex are more anxious after they interact with the program, and that anxiety leads to lowered scores in the subject the program was intended to teach. "However, this only occurs if the children are using the program in public, that is, in a computer lab with other children present," say the authors. "When the programs are used privately, these differences do not emerge." Huff and Cooper conclude that not only is the software sex-stereotyped due to designers' expectations, but that the situation in which the software is presented is at fault.

Challenging Dijkstra: Software Packages vs. Procedural Programming?

One exploratory idea proposed by Danielle Bernstein, associate professor of computer science at Kean College, Union, NJ, was a new curriculum paradigm for computer science education—using software packages instead of procedural programming as an introduction to computer science. She has designed and taught an advanced course, "Conceptual Understanding of Software Packages," which requires previous computing knowledge but which illustrates that packages "have a place" in computer science education. Her next step is to design a course introducing computer science fundamentals with packages.

According to Bernstein, researchers have shown that previous experience, feelings of self-efficacy, and mathematical ability, are major predictors of success in computer science courses. Defining self-efficacy as "the feeling that one is in control of the machine and can make a difference in the operation of the machine," Bernstein said that this factor, which differs between men and women, may cause women's lower level of achievement in computing. Previous experience often leads to feelings of self-efficacy, she said, and much of that experience results from self-initiated investigations outside of classes. "How can we offer women the same experience?" she asked. Again, citing other researchers, she noted that while men may be passionate about computers, women use computers as tools for solving problems. When women do not see computers as efficient tools, they lose interest, but when both sexes see computers as tools, they perform equally well. But given the current computer science curriculum including BASIC, Pascal, and the emphasis on step-by-step division of functions, and formal planning in formal languages, women lose interest, she said.

Arguing for her new approach, Bernstein said that software packages are less tied to mathematics and allow students to do something functional quickly. Because software packages "do real work real soon," she said, "women, who perceive computers as tools rather than toys, would see the purpose of computers." Initial success and accomplishing work bring immediate gratification; exploration is easier and more natural, and mistakes are less costly and visible with databases. Group work, which women prefer, occurs more spontaneously with packages, Bernstein added.

But is this computer science? Yes, according to Bernstein. Software packages can provide a superior introduction to computer science compared to procedural languages. Teaching sophisticated applications

The Workplace in the Late 1980s
A Dialogue on Systers—Industry vs. Academia:

". . . all my professional life I wanted to teach in a university. I have not done it due to a combination of the two-body problem and child-rearing choices. . . I have often wondered whether I am atypical of women in industry research (at least those who have the Ph.D. training to be at a university)."

". . . getting tenure while working part-time . . . is definitely not possible. However, when the choice involves working full-time, I think both situations [academia and industry] are difficult and I am not convinced that one is that much more difficult than the other . . ."

". . . the clear advantage of industry over academia is that it's often possible to work part-time for a finite period (say, a few years), and then return to full-time work without having totally destroyed one's career. That simply isn't true in academia, where the years one wants to work part-time often overlap with the very years in which one is working toward tenure . . ."

"I would certainly encourage women who are hoping to combine family and career to consider academic life. I am concerned that this tenure process is scaring too many women away from the universities. . . . I read that women, more than men, fear failure. Men are much more able to accept failure. Are women not going into academia because they fear the possible "tenure failure" more than men?"

". . . There was an article in Chronicles of Higher Education about 3 years ago by a male professor who wrote about how he and his wife (also a professor) needed to have a third party—a wife . . . The gist of his argument is that faculty workload is based on antiquated notions of unquestioning, full-time support from a spouse, and that universities need to revise their expectations of professors . . . So the question is: how do we help universities enter the twentieth (almost 21st) century?. . ."

Several years ago, a male, American colleague who worked in Geneva . . . said that many of the single women at his facility worked so many hours they had no time for a personal life. They believed that their hard work would be rewarded; their management took advantage of their willingness to please and encouraged them but did not reward them. . . .I have seen this phenomenon repeated many times in both the industrial and academic worlds. . . .Many may not see this as sex related, but I believe it is another example of women playing by one set of rules and men by another."

One final quip from a woman with thirty years of experience:

"Men still make sexist remarks to me, but I fend much better than I did in the 60s. Like the younger women, I'm not saying that attention is bad . . . But I'm much more often complimented for my dress, my hair, or my accent than for the content of what I say and do. So I just turn the compliments around and tell men how pretty their ties are, or how the cut of their jackets bring out their broad shoulders, or how warm their voices are, etc. They squirm under such scrutiny just as we do."

can illustrate and reinforce computer concepts like files, records, fields, memory, secondary storage, Boolean operations, and the format versus content of variables, she said. Packages involve data structures, word processing deals with string data, and spreadsheets have implied structures. In database management systems, the user actually defines the data structure, whereas with Cobal and Pascal the data structures are contained in the programs. "These topics (files, records, etc.) can be examined without the overhead of extensive program planning or syntax problems that can get in the way for a beginner," said Bernstein. "Students may then be able to transfer these concepts to procedural programming successfully."

Referring to a debate on teaching computer science, which appeared in the December 1989 issue of this publication, and specifically to Edsger Dijkstra's article, "On the Cruelty of Really Teaching Computing Science," Bernstein challenged his proposal to turn an introductory programming course into one on formal mathematics. Such a course would use an unimplemented programming language "so that students are protected from the temptation to test their programs," she said, quoting Dijkstra. Bernstein disagrees with this approach because it would discourage those who want to "see, tinker, experiment, and interact" with computers in order to understand principles. And so, she says, Dijkstra's approach would cause computer science majors to further dwindle.

In concluding her paper, Bernstein wrote: "The teaching of soft-

A Study of Gender-Related Studies of Computing

Research methods in much of the literature on sex differences and computing are slipshod and results murky according to Robin Kay, a statistician at the University of Toronto who also presented findings at the workshop. After studying 90 such papers published during the past five years, Kay claims a chaotic collage of definitions clouds results in this rapidly growing domain. Most studies attempt to understand the dynamics of how males and females differ in their interactions with computers by using a "descriptive paradigm," he said. For example, researchers gather statistics on attitudes in computing aptitude, and computer use. But there is no consensus on definitions of these phenomena, and sometimes definitions overlap.

Kay found that "attitude to computers" has been defined in 15 different ways with respect to acceptance, including cognition, confidence, and course enrollment. "Aptitude" has been defined with respect to general application software, awareness, experience, terminology, the LOGO programming language, general programming, word processing, and games. And "use" has been defined as computer camp participation, course enrollment, games, and ownership. Such a "collage of definitions" leads to conflicting reports of results. These can be as sweeping as statements that boys have a more positive attitude to computers than girls, for example, while other reports claim the opposite. Therefore, the most that can be said about gender differences and all three phenomena—attitude, aptitude, and use—is that "it depends on what attitude you measure, what skills you assess, and what use is being made of the computer," said Kay.

But the variety of definitions is by far not the only contributor to conflicting results, said Kay. Slipshod statistical practices, like using too few subjects with too many variables, violate statistical assumptions and cloud interpretations of data. Researchers lump together different age groups—for example, kindergarten through grade 12 students—even though attitudes and knowledge development would be expected to differ between 5-year-old children and 17-year-old adolescents. Worse, some researchers describe their samples inadequately so other researchers cannot knowledgeably evaluate the impact of unmentioned factors.

Kay acknowledged that perhaps the complexity of computer behavior justifies complex explanations. But he suggests instead that there are inconsistent methodologies and interpretations of results because the field is in a preparadigm period of development. He believes the time is ripe for a shift from descriptive, statistical methods that focus on what the behavior is, to qualitative methods that can explain *why* males and females differ in their behavior. The current survey method does not bring researchers close enough to the process behind human computer interaction, Kay says. Therefore, like Sherry Turkle and Seymour Papert (See Additional Reading list), he advocates observation and analysis of natural or real work situations. Although both methods have their strengths and weaknesses, without a shift to qualitative methods, the field will continue to report only pieces of the puzzle and fail to develop a comprehensive theory.

In his paper, Kay suggests that this growing area of research might lead to over-emphasis on the role gender plays in human-computer interaction. Other variables, like ownership, math courses, experience, and general education seem to be more important, according to some theorists. Kay's work, in press at the time of the workshop, shows that cognitive attitude, awareness, and application software surpass gender in predicting commitment to computer use. "It might be more efficacious, then, to assess how gender fits into the whole equation of variables determining computer-related behavior. Comparing sexes on a long list of items tends to obscure process and dynamics issues. Gender is but one piece of the human-computer puzzle."

—K.A.F.

ware concepts has paralleled the advances in software development. Each time functional software has gotten further away from the details of the hardware, there has been a cry that computer science is being watered down. But each step has encouraged more diverse people to deal with computers. Serious conceptual understanding of application packages will continue this trend." At the workshop, she stated, "To me, (Dijkstra's approach) means, 'Computer science is getting too easy. Let's keep the riff-raff out.'"

Academia vs. Industry

Those women with an interest in computer science who do begin preparing for advanced degrees face enormous barriers, according to Henry Etzkowitz, associate professor of sociology at SUNY Purchase and visiting scientist at Columbia University's Computer Science Department. Funded by the NSF, his study, co-authored by Carol Kemelgor and Michael Neuschatz, is titled "The Final Disadvantage: Barriers to Women in Academic Science and Engineering." The study encompasses women in computer science, electrical engineering, chemistry and physics. At a leading research university 350 students and 76 dropouts were identified; they and their faculty were interviewed; and data were collected from academic records to determine the receptivity of their cultures to women graduate students and faculty. "Our specific aim was to determine whether national background of faculty members was associated with bias toward women graduate students," said Etzkowitz. He found that while fewer women had nonwestern faculty advisors, those who did reported less bias toward women as scientists. This was particularly true when the faculty advisors were Chinese and Indian. For these faculty, women clearly held secondary social status, yet sexual identity was viewed as separate from work, Etzkowitz explained. "This separation allowed them to view women as scientists without confusion among sexual identity, occupational, and social status." Male faculty members from Mediterranean and Middle Eastern countries, on the other hand, were most often reported to be prejudiced against women. Etzkowitz also found "sexual separation of scientists," that is, certain areas of science are labelled as peculiarly male or female, which leads both sexes to avoid certain areas. Computer science theory, for example, is de facto off limits to women, in much the same way as particle physics. But natural language is assumed by some male faculty to be more suited to women because it is closer to traditional sex and work roles—like women's "traditional expressive role and typing skills in software."

Etzkowitz found mismatched expectations between male faculty members and female graduate students; female students want to be taught the strategies needed to compete and bolster self-confidence, which male faculty presume means wanting "explicit direction in the conduct of research." These faculty thought female students wanted to be told what to do and how to do it, whereas the students reported that they wanted "guidance on how to succeed in the profession."

Female students in computer science reported both overt and subtle discrimination with "acute consequences," said Etzkowitz. Their self-confidence, ability to perform, and career advancement suffered. Not surprisingly, women seek out female faculty. But unlike men, who sign up with a female faculty member only after she has distinguished herself in the field, female students sign up because they want a sympathetic mentor. One solution found by electrical engineering female graduate students was to undertake research in industry, where they were often able to find women mentors.

Another factor pushing women from academia to industry is the "tenure clock versus the biological clock." One woman in Etzkowitz's study went to work for IBM immediately upon graduating and did not even consider getting a Ph.D. until after her children were born. For her, as for most women, the academic route and tenure were incompatible with having a family. In computer science, "pregnancy is discouraged and graduate women who have children are encouraged to take leaves of absence that tend to become permanent withdrawals." Women expect this and it creates anxiety. Once they have their degrees, going into academia part-time is infeasible and leaves of absence often result in permanent attrition. According to Etzkovitz, these women find they must choose between two approaches: they can either follow the "male model" for success in academia, which demands driven, if not obsessive devotion before tenure, and the publish-or-perish pressures that can lead to exploiting as many students as possible. Or they can go into industry, where their jobs are more nine-to-five and it is a little easier to balance their career and family needs. Relatively few women adopt the first model and more adopt the second, he said.

Etzkowitz concluded that structural barriers could be reduced with the development of a critical mass of women faculty and graduate students in computer science departments. He proposed changing the tenure structure to allow a more flexible timeclock and involving students and faculty in the faculty-recruiting process. He suggested that aggressive intervention was needed on the part of funding agencies to ensure these changes.

Recommendations

After the presentations, the workshop divided into working groups that recommended ways to expose, attract, and retain females in computing. Valerie Clarke, a social psychologist at Deakin University, Australia, spoke for the exposure group, which focused on precollege computer experiences and opportunities. Although this group thought it should address the entire curriculum through 12th grade, for practical purposes, it focused on middle schools only. This stage is crucial because from ages 11 to 14, "children of *both* sexes tend to turn away from computers," Clarke said. "Most children at the primary level have an interest in computers, if given the opportunity, but in the middle school peer pressure tends to direct more girls away from computers." In addition, at this age girls' preferences for working in groups and their needs for demonstrated relevance are especially great.

The group stressed the need for a more ambitious, comprehensive curriculum through twelfth grade *bearing in mind resources.* "It's fairly useless to devise a curriculum that assumes you'll have one computer per two or three children when schools have nothing of the sort," said Clarke. Noting inadequate educational software and teacher training, Clarke said that as a result many teachers may lack confidence and self-esteem. In turn, they fear that their students know more than they do. So while it is very important to provide teachers with curriculum, that is not enough; measures must be taken build teachers' confidence so that they use the curriculum and feel sufficiently in control.

Alluding to studies indicating that a girl's potential depends to some extent on her mother's level of education, Clarke said we must address the more general education of the public through advertising and the media. Good will and a first-class curriculum cannot counter mothers who want to withdraw their children from classes or even schools if their daughters do poorly in computers, said Clarke.

As presented by Danielle Bernstein, the retention group noted that women and disadvantaged groups, find computing courses more time-consuming than other courses and feel they do not receive the right number of credits for the number of hours worked. "They can get the same three credits for a marketing course, where they just read a book and understand it," she explained. And chemistry and physics labs do not demand indefinite periods of time for problem solving. To motivate these credit- and time-conscious students, the group suggested structured labs with exercises that can be finished before leaving class. Such labs could also reduce the computer culture brand of competitiveness that arises when people brag about the many hours they have spent on a system in order to get the best solution.

Looking at how students are taught to write code, this group suggested encouraging students to read programs. To learn most subjects, especially foreign languages, students do not just write, they also learn how to read, said Bernstein. "Computing seems to be the only subject where we teach people how to write without giving them any kind of mental model. A better way is [to include] reading programs," Bernstein said.

This group also addressed computer access. Since students perform better in private, the group sought ways to help all students afford their own computers for use in dorm rooms. It was suggested that colleges bury the price of computers in tuition so they would fall within expenses covered by student loans. Computers in dorm rooms would also give each student a sense of control; the student alone would know and have access to his or her hard disc's contents, for example. "When you control the environment, you have more self-confidence. Otherwise it's like cooking in somebody else's kitchen: you don't know where anything is," Bernstein said.

To encourage high school students to pursue computing in college, the group recommended that college computer science departments "adopt" high schools. Also suggested was cascading pairing; graduate students would pair up with college students, college students with high school students, and so on. This cascading effect at lower levels would decrease dependence on those female computer science professors who are role models, said Bernstein.

Industry should also provide role models: there should be a large-scale program for guest lecturers from industry to speak to high school students. In addition, industry should bring in not just college but high school students to work on projects. To attract industry employees and prevent them from regarding this as mandatory drudge work that siphons time away from their jobs, the group recommended that companies be responsible for rewards systems, but did not specify what kinds.

To widen students' perspectives on career choices, the group suggested inviting not just alumnae who had been A+ students, but those who got Bs and Cs. Through their visits, the current student body would learn that many people with less-than-perfect academic records are very successful in the job market, Bernstein said. Dianne Martin then commented, "We will know we have arrived when it's OK for women to get Cs in science, math, engineering, and computer science. Right now, if you're not an A or B student, you don't even think of going into those fields." The women currently in the field are the high achievers only, she said. "We're not reaching the middle and average achievers. Yet there are average-achieving men going into those fields."

Adding to that group's recommendations, Carol Edwards called for more financial aid, particularly in the form of grants. "When Reagan switched from grants to loans, it hurt the poorest people. It didn't hurt the people that he said were using the money to buy stereos when they go to college," she said. The poorest people—women of color who might have small children—just did not see themselves going into that much debt and being able in the end to pay it off, she said. Edwards also called for tenure and promotion for superior teaching. "Just as we have people who at this point get tenure because of their research," she said, "we also have to look at superior teaching as a criterion for the tenure track."

In his summary of the attraction workgroup's recommendations, Robin Kay echoed the need for parent education. We see stereotyping in the kinds of toys parents encourage their children to play with, and parents often assume that little boys should have more access to computers. "Parents are more inclined to buy boys computers, and if you have a computer at home when you're young, you get used to it." To ensure that girls are not excluded, we should encourage the tool approach to computers, he said. The advent of microcomputers allows this now because, unlike the late '70s and early '80s when you had to know programming in order to use computers, with personal computers "we have become more individualistic. You can do lots more tool-oriented [tasks] with computers and you don't need to program."

And finally, regarding sex biases in software, Kay commented that companies believe their market is male. Further, they think that if they start advertising to females, they may discourage the males, Kay said. He suggested trying to convince companies that there is a viable female market they are cutting off. "If they accept that, they'll think they can make more money. Money does make things happen."

In closing, Martin commented that the "most astounding two words today were 'cumulative disadvantage.'" They indicate priorities as to where energy and resources should be allocated. "It turns out, that if you're a woman, and you're poor, and you're a minority, the disadvantage is cumulative. That's where we have to put cumulative resources. The research shows, without a doubt, that there is this cumulative effect."

If the issues discussed here are not addressed, everyone stands to lose. The profession could find itself asking uncomfortable questions too late in the game. As it is, one wonders how many ideas, that could have been contributed by female talent, will never surface to enrich academic computer science. More broadly, what are the repercussions to our increasingly computer-oriented society, if women—about half the population and professional workforce—are not as prepared in this discipline as are men? Perhaps we will not have to find out.

Workshop Participants

Unless otherwise indicated, papers based on workshop presentations are as yet unpublished.

Chair:

C. Dianne Martin, assistant professor, George Washington University Department of Electrical Engineering and Computer Science, Washington, D.C.
"The Power of Paradigms."

Presenters and Attendees:

Danielle R. Bernstein, associate professor, Department of Mathematics and Computer Science, Kean College of New Jersey, Union, N.J.
"A New Introduction for Computer Science."

Sharon Burrowes Yoder, School of Education, University of Oregon, Eugene, Oregon.

Valerie Clarke, associate professor, Department of Psychology, Deakin University, Victoria, Australia.
"Girls and Computing: Dispelling Myths and Finding Directions."

Carol E. Edwards, director of Project Micro, Southern Coalition for Educational Equity, Atlanta, Georgia.

Henry Etzkowitz, associate professor of Sociology at SUNY Purchase, and visiting scientist, Department of Computer Science, Columbia University.
Co-author with Carol Kemelgor and Michael Neuschatz, "The Final Disadvantage: Barriers to Women in Academic Science and Engineering." NSF Sociology Program Grant #SES-8913525.

Cindy Meyer Hanchey, associate professor, Computer Science Department, Oklahoma Baptist University, Shawnee, Okla.
"Gender Equity—A Partial List of Resources," reprinted here, in part.

Charles W. Huff, assistant professor, Department of Psychology, St. Olaf College, Northfield, Minn.
Co-author with Joel Cooper, "Sex Bias in Educational Software: The Effect of Designers' Stereotypes on the Software They Design." *Journal of Applied Social Psychology, 17,* (June 1987), 6. pp. 519–532.

Robin Kay, research assistant, University of Toronto, Ontario, Canada.
"Understanding Gender Differences in Computer Attitudes, Aptitudes, and Use: An Analysis of Method." Parts I and II.

Lesley S. Klein, instructor of information systems, Computer Science Department, Pace University, Pleasantville, NY.
"Female Students' Underachievement in Computer Science and Mathematics: Reasons and Recommendations."

Jenelle Leonard, computer coordinator, District of Columbia Public Schools, Washington, DC.

Carol Wolf, chair, Computer Science Department, Pace University, New York, N.Y.

Elizabeth Wolf, representing ACM Committee on the Status of Women in Computer Science, graduate student, Stanford University, Palo Alto, Calif.

Additional Reading

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Technical Assistance Modules:
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—Federal Statutes and Directives Regarding Title IX Compliance
—Civil Rights Compliance: An Update

Training Modules:
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- II Integrating the ESL Student into the Content Area Classroom
- III Recognizing Cultural Differences in the Classroom
- IV Sex Stereotyping and Bias: Their Origin and Effects
- V Modeling Equitable Behavior in the Classroom
- VI Avoiding Sex Bias in Counseling
- VII Equity in Counseling and Advising Students: Keeping Options Open
- VIII Interpersonal Communications: A Human Relations Practicum
- IX It's a Matter of Race: Race Relations in the Desegregated Setting

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CR Categories and Subject Descriptors
K.7.1 **[The Computing Profession]:** Occupations
K.4.2. **[Computers and Society]:** Social Issues
K.3.1 **[Computers and Education]:** Computer and Information Science Education —Computer Science education, curriculum, Information systems education, self-assessment